EOCENE – OLIGOCENE CALCAREOUS NANNOFOSSILS FROM HUEDIN AREA, BETWEEN HODIȘ AND TETIȘ (TRANSYLVANIA, ROMANIA): BIOSTRATIGRAPHY AND PALEOECOLOGICAL DATA

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ABSTRACT. Eocene - Oligocene deposits from Huedin area, between the localities Hodiș and Tetiș, of the Transylvanian Basin, have been analysed. The assemblages of calcareous nannofossils are rich in the Brebi and Mera formations and relatively scarce in almost all other formations.

Keywords: Eocene, Oligocene; Transylvania: Huedin region, calcareous nannofossils, NP15 – NP23, biostratigraphy, paleoecology.

I. INTRODUCTION

In the investigated area of Huedin region, between the localities Tetiș and Hodiș, the Paleogene deposits are represented by Paleocene, Eocene and Oligocene sediments (Fig. 1). Until now these deposits have been studied regarding the calcareous nannofossils, in the neighborhood area of Huedin, at Morlaca, Văleni and other localities.

In the area of Hodiș and Tetiș, the previous studies concerned the molluscs, echinids, foraminifera, ostracods, a. o. groups of organisms.

This is the first study concerning the calcareous nannofossils from the mentioned sections of Tetiș and Hodiș.

The geological studies in the region of Huedin belong to Hauer & Stache (1863), Koch (1894), Moisescu (1975, 1978), Moisescu et al. (1991), Rusu (1970, 1977), Popescu (1978), Popescu et al. (1978), Gheța (1984), Mészáros (1957, 1960, 1991), Mészáros and Ianolii (1989), Mészáros and Nicorici (1987, 1989), Mészáros et al. (1989, 1991), Mălan (1996), Chira (1989a, 1989b) Hosu (1999), a.o.

II. GEOLOGICAL SETTING

The lithostratigraphic units present in the Huedin area are given after the stratigraphical studies realized by Rusu (1970, 1977), Moisescu (1975), Popescu (1978), Bombiță (1963), Hosu (1999), a.o. and synthetized by Filipescu (2001).

The Jibou Formation (Late Maastrichtian – Late Lutetian) is a continental lithostratigraphic unit which consists of red siltic clays, sands and conglomerates.

The Foidaș Formation (Late Lutetian) is a marine lithostratigraphic unit represented by clays, dolomites, limestones and gypsum.

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Fig. 1. Location map of the studied area (Hodiș - Tetiș). Legend: 1. Quaternary, 2. Badenian, 3. Chattian - Aquitanian, 4. Rupelian, 5. Priabonian, 6. Lutetian, 7. Ypresian, 8. Andesite - Early Paleogene, 9. Dacite - Early Paleogene, 10. Overthrust Fault, 11. Fault (after the geological maps 1:200.000 – Dumitrescu, 1968 and Patrulius et al., 1968, with modifications).

The Căpuș Formation (Late Lutetian – Bartonian) consists of clays, limestones, a *Pycnodonte brongnarti* level, a *Sokolovia eszterhazyi* biohorizon and a *Nummulites perforatus* level.

The Mortănuşa Formation is represented by:

- Inucu Member (Bartonian), a normal marine unit represented by marls and limestones, with a *Crassostrea bersonensis* biohorizon;
- Văleni Limestone (Bartonian);
- Ciuleni Member (uppermost Bartonian – lowermost Priabonian) is represented by marls, sands and a *Crassostrea orientalis* biohorizon.

The Viştea Limestone (Priabonian), with shallow marine deposits, is represented by calcarenites, biomicrites and dolomicrites with siliciclastic intercalations.

The Valea Nadăşului Formation represents the second continental litho-stratigraphic unit which consists of a lower sandy sequence and an upper red clay sequence (Hosu, 1999).

The Jebuc Formation is represented by fresh-water and evaporitic deposits, represented by clays, limestones with *Anomia*, dolomicrites and gypsum.

The Cluj Limestone, which in the lower part is a porous skeletal wackestone and in the upper part a packstone with terrigenous grains, deposited on a carbonate platform, contains the following biohorizons: *Crassostrea transivanica*, then *Vulsella*, *Campanile* and echinoids biohorizons, and *Nummulites fabianii* biohorizon.

The Brebi Formation is a siliciclastic formation with bryozoans, limestones and *Pycnodonte gigantica* biohorizon, considered a marker for the boundary between the Priabonian and the Rupelian.

The Mera Formation is represented by clays, sands, sandstones and bioclastic limestones and is bounded by two levels with *Scutella subtrigona*.

The Hoia Limestone is a skeletal packstone which appear locally, in the lowermost part of the Mera formation.

III. EOCENE-OLIGOCENE CALCAREOUS NANNOFOSSILS ASSEMBLAGES FROM THE TRANSYLVANIAN BASIN AND ESPECIALLY FROM HUEDIN AREA: HODIŞ-TETIŞ

The investigated **Eocene** calcareous nannoplankton assemblages belong to NP15 – NP21 zones and the **Oligocene** ones belong to NP22 – NP23 zones, according to the Standard Nannoplankton Zonation (Martini, 1971).

At Hodiş, nearby Huedin, all the terms of the Eocene - Oligocene from Transylvania are present. The richest and most diversified calcareous nannofossils assemblages were found in the Brebi (NP21, NP22) and Mera formations (NP22, NP23).

On the Peşterii Valley, at Hodişu a tectonic semiwindow is present.

Along the Peşterii Valley, the Foidaş Formation (the equivalent of “Lower Gypsums”, after Popescu et al., 1978) is constituted of a 4 m thick sequence of dolomicrites stratified in decimetric beds with centimetric joints of greenish clays. The evaporite formation marks the first penetration of marine waters during the Eocene in the Transylvania Depression.

Within the Căpuş Formation, the calcareous nannofossils assemblage consists of: *Reticulofenestra hampdenensis*, *Micrantolithus basquensis*, *Pemma rotundum*, *Braarudosphaera bigelowii*, *Rhabdosphaera inflata*, *R. crebra*, *Blakites spinosus*, *Neococcolithes protenus*, *Zygrablihus bijugatus* (above the *Gryphaea*

brongniarti level, according to Gheța in Popescu et al., 1978), and: *Reticulofenestra umbilica*, *R. hampdenensis*, *Neococcolithus dubius*, *Sphenolithus furcatolitoideus* (one meter below the *Nummulites perforatus* level). It was mentioned that the assemblage is not varied specifically; the genera *Chiasmolithus* and *Discoaster*, utilised for the standard zonation of the Middle/Upper Eocene interval are lacking. As the most significant event within the "Lower Molluscan Marls" was mentioned the occurrence of *Reticulofenestra umbilica*, placed approximately towards the upper part of the Middle Eocene and corresponding to the upper half of the NP15 Zone (*Chiphragmalithus alatus* zone after Martini, 1971). Near Hodiș are mentioned two lumachelle beds with *Nummulites perforatus* separated by a sandy layer with molluscs, alveolinids and nummulites.

The Căpuș Formation (Late Lutetian – Bartonian) was included on the NP15 – NP16 biozones (Mészáros, 1991).

In the lower part of the Mortănușa Formation ("Upper Molluscan Marls") the nannoplankton assemblage was considered resembling to that of the Căpuș Formation. Only *Reticulofenestra hampdenensis* has an increased frequency. This stratigraphic interval was also ascribed to the *Reticulofenestra umbilica* Zone, namely the Upper Middle Eocene (Gheța in Popescu et al., 1978).

The nannoplankton belongs to the NP16 – NP17 (Gheța, 1984, Mészáros, 1991); Ciuleni Member (uppermost Bartonian – lowermost Priabonian) is represented by marls, sands and a *Crassostrea orientalis* biohorizon (NP 17 – NP18) (Mészáros, 1991).

Within the lower half of the "Gray Clays and Marls" (Inucu Member of the Mortănușa Formation), at Leghia, the nannoplankton assemblage was considered to be almost the same as the one from the "Lower Molluscan Marls" and to belong to the upper part of the *Reticulofenestra umbilica* Zone, more precisely to the *Discoaster saipanensis* subzone. The Middle/Upper Eocene boundary was placed in the upper half of the "Gray Clays and Marls" (Gheța in Popescu et al., 1978).

The "Leghia Limestone" (Văleni Limestone) is generally made up of two beds separated by a marly joint which at Hodiș reaches some 3 m in thickness (Fig. 2). It is a bioclastic calcarenite whose bioclasts are: corallinaceae, echinoderms, benthic microforaminifera and alveolinids. A nearshore fauna with a sandy substratum of an euhaline marine basin was mentioned (Popescu et al., 1978).

One of the most complete section for Valea Nadășului Formation was remarked along Peșterii Valley from Hodiș, but some faults are fragmenting the sequence. A level bearing fresh water gastropodes crops out along this valley, near Hodiș. On the Peșterii Valley, at Hodiș, dolomicrites of only 20 cm thick, stratified as centimetric beds were remarked ("Upper Gypsum", respectively the Jebuc Formation).

Generally, within the Cluj – Huedin area, the Cluj Limestone begins with a sequence of marly limestone or sandy marls with *Anomia*, *Vulsella* and a typical molluscan fauna. Westwards, to Hodiș, at Peșterii Valley, the lumachellic level with *Crassostrea transilvanica* was not remarked. A Mediterranean molluscs fauna within which boreal elements occur, was mentioned (Gheța in Popescu et al., 1978). The nannoplankton assemblage is very poor. To the top of this formation, *Istmolithus recurvus* was found, which might have most probably appeared at a much lower level.

Fig. 2. Legend: 1 - Coralle limestone, 2 - Gypsum, 3 - Limestone, 4 - Marls, 5 - Sand, 6 - Sandstone.

The Cluj Limestone, which in the lower part is a porous skeletal wackestone and in the upper part a packstone with terrigenous grains, deposited on a carbonate platform, contains the following biohorizons: *Crassostrea transilvanica*; *Vulsella*, *Campanile* and echinoids; and *Nummulites fabianii*. The nannoplankton was included in the NP19 - NP20 zones (Mészáros, 1991).

Near the Hodiș village, along the Peșterii Valley a graded transition between the Brebi Formation and the Hoia Limestone was observed. Here, within a few centimeters, the "Brebi marls" turn into calcareous marls with tubular or palmate corals, then into a coraligenous limestone 20 cm thick. Some 200 m south along a stream parallel to the Peșterii Valley, the coraligenous Hoia Limestone, 45 cm thick, overlies without transition, the slightly sandy or silty "Brebi Marls".

The Brebi Formation nannoplankton assemblage is rich and quite varied.

In the upper part of the Cluj Limestone numerous specimens of *Istmolithus recurvus* were remarked (Gheța in Popescu et al., 1987). It was considered that it is possible that this species made its first appearance at a time corresponding to the Valea Nadășului Formation or even older. From the nannoplankton assemblage of the Brebi Formation made up of about 40 species (Popescu and Gheța, 1972; Martini and Moisescu, 1974; Popescu et al., 1978), more frequent and important are: *Istmolithus recurvus*, *Sphenolithus predistentus*, *Reticulofenestra umbilica*, *Dictyococcites bisectus*, *Cyclicargolithus floridanus*, *Ericsonia subdisticha*, *Lanternitus minutus*, *Coccolithus formosus*. It was observed the lack of discoasterids in this Upper Eocene assemblage. This might be due to some local ecological or paleoenvironmental conditions. The nannofossil assemblages were included in the NP19 – NP21 biozones, ranging from the upper part of the Cluj Limestone to the *Pycnodonte gigantea* level of Brebi Formation (Gheța in Popescu et al., 1978). The *Coccolithus formosus* extinction above the *Pycnodonte gigantea* level marks the boundary between NP21 and NP22 zones, corresponding to the Priabonian/Rupelian boundary.

The Brebi Formation is a siliciclastic formation with bryozoans, limestones and *Pycnodonte gigantea* biohorizon - considered as a marker for the boundary between Priabonian and Rupelian (NP21 – NP22).

The Mera Formation is represented by clays, sands, sandstones and bioclastic limestones and it is bounded by two levels with *Scutella subtrigona* (NP22 – NP23).

The Hoia Limestone is a skeletal packstone which occurs locally, in the lowermost part of the Mera formation (NP22).

It was remarked that only the Călata (Racoczy) Group (Foidaș, Căpuș, Mortănușa formations and Viștea Limestone or Racoczy Sandstone) (Lutetian – Bartonian – Early Priabonian) and the Turea (Cluj) Group (Jebuc Formation, Cluj Limestone, Brebi Formation, Hoia Limestone and Mera Formation) (Priabonian – Rupelian) yield calcareous nannofossils, with rich and well preserved assemblages, excepting the Viștea (Leghia) Limestone and the intervals containing gypsum (Gheța, 1984). For the rich and varied assemblages exhibited by the upper members of the Eocene sequence the standard zonation of Martini (1971) was used. For the lower members, where the index species are missing, Gheța (1984) had proposed another zonation, which consists of: *Reticulofenestra primitiva* zone – correlated with the NP16 zone - *Discoaster tani nodifer* zone; *Rhabdosphaera inflata* zone was correlated to the upper part of NP16; *Reticulofenestra bisecta* zone, equivalent

to NP17 - *Discoaster saipanensis* zone; these are followed by NP18 - *Chiasmolithus oamaruensis* zone; the NP19 – *Istmolithus recurvus* zone was not recorded; NP20 – *Sphenolithus pseudoradians* zone; NP21 – *Ericsonia subdisticha* zone and NP22 – *Helicosphaera reticulata* zone – in the upper third of Brebi Formation, between the *Pycnodonte gigantea* level and the Mera Formation.

Middle Eocene/ Upper Eocene boundary could be established in the upper part of Mortănuşa Formation.

The Hoia Limestone ended the marine sedimentation of the Priabonian. The calcareous nannofossils belong to the NP22 zone.

In the Văleni area, south from Huedin, Mălan (1996) has identified three nannofloristic assemblages: the first one was included into the regional biozone *Reticulofenestra primitiva* proposed by Gheţa (1984), for Transylvania and correlated with the subzone CP 14a (Okada and Bukry, 1980). It was considered to be specific for the terminal part of the Foidaş Formation and for the basis of the Căpuş Formation. The upper part of the Căpuş Formation and the Inucu Beds have been characterized by an assemblage assigned to the CP14a respectively NP16. The Mortănuşa Beds have been characterized by an assemblage assigned to the biozones CP14b (Okada and Bukry, 1980), respectively NP17 (Martini, 1971). The deposits were assigned to the terminal Lutetian (Foidaş and Căpuş Beds) and to the Bartonian (Inucu, Văleni and Mortănuşa Beds).

Table 1.

Representative calcareous nannofossils from Huedin area: Hodiş and Tetiş
(according to the classification of Young & Bown, 1997).

NANNOFOSSIL SPECIES	Hodiş	Tetiş
CALCAREOUS NANNOPLANKTON: HETEROCOCCOLITHS		
Family Pontosphaeraceae		
<i>Pontosphaera multipora</i> (KAMPTNER, 1948) ROTH (1970)	x	X
<i>Pontosphaera pulchra</i> (ROMEIN, 1979)	x	
<i>Pontosphaera latoculata</i> (BUKRY & PERCIVAL, 1971) PERCH-NIELSEN, 1984	x	
<i>Pontosphaera obliquipons</i> (DEFLANDRE, 1959)	x	x
<i>Pontosphaera lateliptica</i> (BALDI-BEKE & BALDI, 1974) PERCH-NIELSEN, 1984	x	
<i>Pontosphaera enormis</i> (LOCKER, 1967 PERCH-NIELSEN, 1984)	x	x
<i>Pontosphaera formosa</i> (BUKRY & BRAMLETTE, 1969) ROMEIN, 1979	x	
<i>Pontosphaera bicaveata</i> (PEARCE-NIELSEN, 1967) ROMEIN, 1979	x	
<i>Transversopontis obliquipons</i> (DEFLANDRE IN DEFLANDRE & FERT, 1954) HAY, MOHLER & WADE, 1966	x	x
<i>Transversopontis pulcheroides</i> (SULLIVAN, 1964) BALDI-BEKE, 1971	x	x
<i>Transversopontis pulcher</i> (DEFLANDRE IN DEFLANDRE & FERT, 1954) PERCH-NIELSEN, 1967	x	x
Family Rhabdosphaeraceae		
<i>Blakites tenuis</i> (BRAMLETTE & SULLIVAN, 1961) SHERWOOD, 1979	x	x
<i>Blakites spinosus</i> (DEFLANDRE & FERT, 1954) HAY & TOWE, 1962	x	x
<i>Rhabdosphaera creber</i> (DEFLANDRE IN DEFLANDRE & FERT, 1954)	x	

NANNOFOSSIL SPECIES	Hodiș	Tetiș
Family Noelaerhabdaceae		
<i>Reticulofenestra umbilica</i> (LEVIN, 1965) MARTINI & RITZKOWSKI, 1968	x	x
<i>Reticulofenestra hillae</i> (BUKRY & PERCIVAL, 1971)	x	
<i>Reticulofenestra reticulata</i> (GARTNET & SMITH, 1967) ROTH & THIERSTEIN, 1972		
<i>Reticulofenestra dictyoda</i> (DEFLANDRE IN DEFLANDRE & FERT, 1954) STRADNER IN STRADNER & EDWARDS, 1968	x	x
<i>Dictyococcites bisectus</i> (HAY, MOHLER, WADE, 1966) BUKRY & PERCIVAL, 1971	x	x
<i>Dictyococites danicus</i> (BLACK, 1967)	x	
<i>Cyclicargolithus abisectus</i> (Muller, 1970) WISE, 1973	x	
<i>Cyclicargolithus floridanus</i> (ROTH & HAY in HAY et al., 1967) BUKRY (1971)	x	x
<i>Cyclicargolithus rupeliensis</i>	x	x
<i>Cyclicargolithus robustus</i>	x	
<i>Cyclicargolithus luminis</i>	x	x
Family Coccolithaceae		
<i>Coccolithus formosus</i> (KAMPTER, 1963) WISE, 1973	x	x
<i>Coccolithus pelagicus</i> (WALLICH, 1877) SCHILLER (1930)	x	x
<i>Coronocyclus prionion</i> (DEFLANDRE & FERT, 1954) STRADNER in STRADNER & EDWARDS, 1968	x	
<i>Coronocyclus nitiscens</i> (KAMPTER, 1963) BRAMLETTE & WILCOXON, 1967	x	
<i>Chiasmolithus gigas</i> (BRAMLETTE & SULLIVAN, 1961) RADOMSKI, 1968	x	
<i>Chiasmolithus grandis</i> (BRAMLETTE & SULLIVAN, 1954) RADOMSKI, 1968	x	
<i>Criboecentrum reticulatum</i> (GARTNER & SMITH, 1967) PERC-NIELSEN, 1971	x	
<i>Ericsonia fenestrata</i> (DEFLANDRE & FERT, 1954) STRADNER IN STRADNER & EDWARDS, 1968	x	
<i>Ericsonia subdisticha</i> (ROTH & HAY in HAY et al., 1967) ROTH in BAUMANN & ROTH, 1969	x	
Cenozoic heterococcolith genera incertae sedis		
<i>Markalius inversus</i> (DEFLANDRE IN DEFLANDRE & FERT, 1954) BRAMLETTE & MARTINI, 1964	x	
HOLOCOCOLITHS		
Family Calyptosphaeraceae		
<i>Zygrabolithus bijugatus</i> (DEFLANDRE IN DEFLANDRE & FERT, 1954) DEFLANDRE, 1959	x	x
<i>Corannulus germanicus</i> (STRADNER, 1962)	x	
<i>Laternitus minutus</i> (STRADNER, 1962)	x	x
<i>Istmolithus recurvus</i> (STRADNER, 1954)	x	
NANNOLITHS		
Family Braarudosphaeraceae		
<i>Braarudosphaera bigelowii</i> (GRAN & BRAARUD, 1935) DEFLANDRE (1947)	x	x
<i>Micrantholithus inequalis</i> (MARTINI, 1961)	x	x
Family Discoasteraceae		
<i>Discoaster cf. tani</i> BRAMLETTE & RIEDEL (1954)	x	
<i>Discoaster tani nodifer</i> BRAMLETTE & RIEDEL (1954)	x	
Family Sphenolithaceae		
<i>Sphenolithus pseudoradians</i> (BRAMLETTE & WILCOXON, 1967)	x	
<i>Sphenolithus predistensus</i> (BRAMLETTE & WILCOXON, 1967)	x	

NANNOFOSSIL SPECIES	Hodış	Tetiş
Family Lithostromationaceae		
<i>Lithostromation perdurum</i> (DEFLANDRE, 1942)	x	
Genera incertae sedis		
<i>Tribraachiathus bramlettei</i> (BROENNIMANN & STRADNER, 1960) PROTO DECIMA et al., 1975	x	
Family Lapideacassaceae Genera incertae sedis		
<i>Biantholithus sparsus</i> (BRAMLETTE & MARTINI, 1964)	x	x
CALCAREOUS DINOFLAGELLATES		
<i>Thoracosphaera</i> sp.	x	x

IV. PALEOECOLOGICAL DATA

By analogy with the present-day climatologically differentiated nannoplankton assemblages, Hay and Lohmann (1976) attributed the early Cenozoic latitudinal differentiation to climatic control. They inferred two marked cooling episodes during the Paleocene – Eocene interval: the first during the middle Paleocene and the second during the middle Eocene, as well as a marked warming event during the late Paleocene and early Eocene, and a second less pronounced warming in the late Eocene.

The exact intervals for the Atlantic Ocean, when the middle Paleocene cooling episode took place, as shown by the migratory patterns of the high latitude *Prinsius martinii* Assemblage were precised. The same for the late Paleocene – early Eocene warming episode – with a warming peak when *Toweius craticulus* Assemblage showed its maximum poleward extent. The middle Eocene cooling occurred when discoasters retreated from relatively mid to high latitudes towards low latitudes. A synchronous slight withdrawal of the Reticulofenestrid Assemblage from higher latitudes was also noticed during interval. A less pronounced warming episode in the late – middle Eocene was characterised by the discoasters return to mid and lower high latitudes in significant number (Haq and Lohmann, 1979).

For the Atlantic Ocean it was remarked that the Eocene reticulofenestrid assemblage appeared once again in the early Oligocene mainly at high latitudes (Haq et al., 1977). Among the other assemblages of the Oligocene the sphenolith – discoaster assemblage dominated the low latitudes. The *Cyclicargolithus floridanus* and *Dictyococcites hesslandii* assemblages were both cosmopolitan assemblages occurring throughout the Oligocene. Thus, in the early Oligocene a marked cooling episode was indicated by the Oligocene high – latitude nannofloral assemblages (reticulofenestrid and *Coccolithus pelagicus*, which extended their range equatorward. The last important Paleogene climatic event was a warming trend in the latest Oligocene, when the low latitude sphenolith – discoaster nannofloral assemblage extended its range into the mid – latitudes, while the high – latitude nannofloral assemblages withdrew from the low latitudes (Haq et al., 1977).

The disappearance in the Paratethys of *Coccolithus formosus*, *Istmolithus recurvus*, and *Clausicoccus* during the Early Oligocene may be due to their low tolerance of the paleoenvironmental changes occurring then: strong temperature lowering, increased seasonality, decrease in salinity or increase nutrient supply. Eutrophication was considered to be one of the determinant agents of the Early Oligocene nannofossil extinctions by Aubry (1992).

The grouping of *Discoaster tani*, *D. nodifer* and *Reticulofenestra umbilica* may characterize open-sea conditions – i. e. low nutrient content and normal salinity. *R. umbilica* had a higher resistance to dissolution, too (Krhovsky et al., 1992).

Several species occur more frequently in near-shore waters: *Pontosphaera multipora*, *Transversopontis pulcheroides*, *Zygrabliothus bijugatus* and *Dictyococcites bisectus*. These require increased nutrient contents and can tolerate greater variations in ecologic conditions: salinity, temperature changes a. o. (Krhovsky et al., 1992).

Chiasmolithus is more frequent at higher latitudes and in shelf sediments (Beckmann et al., 1981).

Based on paleoecological observations, the Paleogene calcareous nannoplankton was subdivided into seven groups by Baldi-Beke (1984), for the Transdanubian region, which indicate the paleotemperature and the distance from the shore, especially: group 1 containing the genera: *Thoracosphaera*, *Scyphosphaera*, *Sphenolithus*, *Discoaster*, *Trochoaster* and *Lithostromation*, which characterize oceanic forms of open sea, preferring mainly warmer climate; Group 2 contains the genera *Coccolithus*, *Cyclacargolithus*, *Cyclococcolithus*, *Cribrocentrum*, *Reticulofenestra*, *Chiasmolithus* and *Crucioplacolithus*, which are considered oceanic forms, characterizing mainly open sea; Group 3 is represented by *Lanternitus minutus*, *Zygrabliothus bijugatus*, *Istmolithus recurvus*, a.o. species. All the species are considered only marine, preferring the near-shore facies; Group 4 contains the genera *Rhabdosphaera* and *Blackites*, which are marine near-shore forms; Group 5 contains the genera *Braarudosphaera*, *Micrantolithus* and *Pemma*, characteristic only for near-shore and with tolerance to decreasing salinity; Group 6 with *Pontosphaera* (= *Discolithina*), *Transversopontis*, *Neococcolithes dubius* are considered typical for the near-shore environment, capable to tolerate a stronger decrease in salinity; Group 7 is characterized by *Reticulofenestra tokodensis* considered characteristic to slightly hyposaline water.

V. CONCLUSIONS

In conclusion, in the Huedin area, the calcareous nannofossils allow us to evidence the presence of the Eocene - Oligocene deposits, belonging to NP 15 – NP23 biozones.

Only for the late Eocene – early Oligocene deposits the marker species from the standard zonations have been identified (Martini's zonation, 1971). For the other formations, the content in calcareous nannofossils is very scarce, and the possibility to integrate the nannoplankton assemblages into the standard zonation is reduced.

At Hodiș, all the terms of Eocene – Oligocene from Transylvania are present. The richest and most diversified calcareous nannofossils were found in the Brebi (NP21, NP22) and Mera formations (NP22, NP23).

REFERENCES

- Aubry, M. P., 1992, Late Paleogene calcareous nannoplankton evolution: a tale of climatic deterioration. In: Prothero D. R., and Berggren W. A. (Eds.): *Eocene – Oligocene climatic and biotic evolution*. Princeton Univ. Press, 272 – 309, Princeton, Oxford.
- Baldi-Beke, M., 1984, The nannoplankton of the Transdanubian Paleogene formations. *Geol. Hung., Pal.*, 43, 307 p., Budapest.
- Bombiță, G., 1963, *Contribuții la corelarea eocenului epicontinental al R.P.R.* Ed. Acad. Rom., 113 p., București.
- Bramlette, M. N., Wilcoxon, J. A., 1967, Middle Tertiary Calcareous Nannoplankton of the Ciperio Section, Trinidad, W. I. Tulane *Studies Geology*, 5, p. 93 - 131.
- Chira, C., 1989a, Macrofaunas from the Oligocene formations in the Transylvanian and Petrosani Basins. In: *The Oligocene from the Transylvanian Basin*, p. 529 – 576, Cluj-Napoca.
- Chira, C., 1989b, Oligocene macrofloras from the Transylvanian and Petrosani Basins. In: *The Oligocene from the Transylvanian Basin*, p. 577 - 589, Cluj-Napoca.
- Dragoș, V., 1966, Paleogenul din regiunea Călățele – Huedin. *An. Inst. Geol.*, 35, p. 347 – 395, 2 figs., 7 pls., București.
- Dumitrescu, I., 1968: *Harta geologică scara 1:200.000, foaia Cluj*. Notă explicativă. București.
- Filipescu, S., 2001, *Cenozoic lithostratigraphic units in Transylvania*. In Field Trip Guide, 4th Regional Meeting of IFAA (Bucur et al., Eds.), p. 75 – 92, Cluj-Napoca.
- Gheța, N., 1984, The Eocene of NW Transylvania. A new biochronostratigraphic zonation based on calcareous nannoplankton. *D. S. Inst. Geol., Geof.*, LXIX, 3, 95 – 106, București.
- Hauer, F., Stache, G. 1863, *Geologie Siebenbürgens*. 637 p., 10 pl., Wien.
- Haq, B. U., 1971, Paleogene Calcareous Nannoflora. Part IV. Paleogene nannoplankton biostratigraphy and evolutionary rates in Cenozoic calcareous nannoplankton. *Acta Univ. Stockholmensis. Stockholm Contributions in Geology.*, XXV, 4, p. 129 – 158, Stockholm.
- Haq, B. U., Premoli-Siva, I., Lohmann, G. P., 1977, Calcareous Plankton Paleobiogeographic evidence for Major Climatic Fluctuations in the Early Cenozoic Atlantic Ocean. *Journal of Geophysical Research*, 82, 27, p. 3861 – 3876.
- Haq, B. U., Okada, H., Lohmann, G. P., 1979, *Paleobiogeography of the Paleocene/Eocene calcareous nannoplankton from the North Atlantic Ocean*. In: Tucholke, B. E., Vogt, P. R., et al., Init. Rep. DSDP, 43, p. 617 - 629, 2 pls., 12 figs., 3 tabs.
- Hosu, A., 1999. *Arhitectura sedimentației depozitelor eocene din nord-vestul Depresiunii Transilvaniei*. Ed. Presa Universitară Clujeană, 224 p., Cluj-Napoca.
- Igritan, A., 2004, *Nannoplanctonul paleogen din arealul Cluj – Huedin: importanță biostratigrafică și paleoecologică*. Lucrare disertație, 49 p., Univ. Babeș-Bolyai, Cluj-Napoca.
- Koch, A., 1894, Die Tertiärbildungen des Beckens der Siebenbürgischen Landestheile. I. Paleogene Abtheilung, *Mitt. Jahrb. der k. ung. Geol. Anst.*, X, 6, p. 179 – 397, Wien.
- Krhovsky, J., Adamova, J., Hladikova, J., Maslowska, H., 1992, Paleoenvironmental changes across the Eocene/Oligocene boundary in the Zdanice and Pouzdrany units (Western Carpathians, Czechoslovakia): the long-term trend and orbitally forced changes in calcareous nannofossil assemblages. *Proced. IV. INA Conf., Knihovnicka ZPN*, 14 b, 2, p. 105 – 187, 10 figs. 4 tab., Prague.
- Locker, v. S., 1972, Coecolithinnen aus dem Paleogen Mitteleuropas. *Paleont. Abh., Abt. B., Paleobot.* 3, 5, p. 735 – 853, 2 Abb., 6 Tab, 17 Taf., Berlin.
- Mălan, L., 1996, Biozonation of the Middle Eocene from Văleni (Călățele Gulf, NW of the Transylvanian Basin) based on calcareous nannofossils. *Studia Univ. Babeș-Bolyai, Geol.*, 39, 1 – 2, p. 337 – 353, 2 figs., 3 figs., 1 tab., 1 pl., Cluj-Napoca.

- Martini, E., Worsley, 1970, Standard Neogene calcareous nannoplankton zonation. *Nature*, 225, p. 289 – 290.
- Martini, E., 1971, Standard Tertiary and Quaternary Calcareous Nannoplankton Zonation. *Proceedings of the II Planktonic Conference*, Roma, 1970, A. Farinacci, ed., Ed. Tecnoscienza, p. 739 - 785, Rome.
- Martini, E., Moisescu, V., 1974, Nannoplankton-Untersuchungen in oligozaenen Ablagerungen zwischen Cluj und Huedin (NW Siebenbuergisches Becken, Rumaenien). *N. Jb. Geol. Palaeont., Mh.*, Jg 1974, H.1, p. 18 – 37, Stuttgart.
- Mateescu, S. I., 1926, Observațiuni geologice și morfologice asupra depresiunii Huedinului din Nord Vestul Transilvaniei. *An. Inst. Geol. Rom.*, 11, p. 349 – 382, 10 figs., București.
- Mészáros, N., 1957, *Fauna de moluște a depozitelor paleogene din nord-vestul Transilvaniei*. Ed. Acad. R.p.R., 174 p., București.
- Mészáros, N., 1960, Studiul litofacial și paleogeografic al depozitelor marine eocen medii de la vest și sud-vest de Cluj. *Studia Univ. Babeș-Bolyai*, II, 1, p. 87, - 104, Cluj.
- Mészáros, N., Nicorici, E., 1987, Problemes majeurs de la stratigraphie de l'éocène de Roumanie dans le contexte de l'éocène europeene avec des references aux limites cretace/paleocene et éocène/oligocène. In: *The Eocene from the Transylvanian Basin*, p. 7 - 16, Cluj-Napoca.
- Mészáros, N., Nicorici, E., 1989, Delimitations et subdivisions de l'Oligocène en Europe et leur applications à differentes régions de la Roumanie. In: *The Oligocene from the Transylvanian Basin*, p. 7 - 16, Cluj-Napoca.
- Mészáros, N., Moisescu, V., Rusu, A., 1989, The Merian, a new substage of the Mesogean Oligocene. In vol. *The Oligocene from the Transylvanian Basin*, p. 31 - 54, Cluj-Napoca.
- Mészáros, N., Ianoliu, C., 1989, Nannoplankton zones in the Oligocene deposits of the North-Western Transylvanian Basin. In: *The Oligocene from the Transylvanian Basin*, p. 157 - 162, Cluj-Napoca.
- Mészáros, N., 1991, Nannofossil Zones in the Paleogene and Miocene Deposits of the Transylvanian Basin. *Proced. IV. INA Conf., Knihovnicka ZPN*, 14 b, 2, p. 87 - 92, 3 fig., Prague.
- Mészáros, N., Moisescu, N., 1991, Bref aperçu des unites lithostratigraphiques du Paleogene dans le nord-ouest de la Transylvanie (region de Cluj-Huedin), Roumanie. *Bull. Inf. Geol. Basin Paris*, 28, 2, p. 31 – 39, Paris.
- Micu, M., Gheța, N., 1986, Eocene-Oligocene Boundary in Romania on the Calcareous Nannoplankton. *D. S. Inst. Geol.*, 70 – 71, 4, p. 283 – 287, 8 figs., 2 pls., București.
- Moisescu, V., Mészáros, N., Chira, C., 1991, Contribution to the revision of the Eocene molluscan fauna from the Cluj – Huedin area (North Western Transylvania) and to its local biostratigraphical distribution. *Studia Univ. Babeș – Bolyai, Geol.*, XXXVI, 2, p. 73 – 83, Cluj.
- Moisescu, V., 1975, Stratigrafia depozitelor paleogene și miocen inferioare din regiunea Cluj- Huedin – Românași (NW –ul bazinului Transilvaniei). *An. Inst. Geol. Geofiz.*, 47, p. 5 – 212, 10 figs., 29 tab., 24 pls., București.
- Moisescu, V., 1978, Biostratigrafia și corelarea depozitelor oligocene din regiunea Cluj (Transilvania de NW). *D. S. Inst. Geol.*, 64, 4, p. 217 – 281, 1 figs., 7 tab., 3 pls., București.
- Okada, H., Bukry, D., 1980: Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973, 1975). *Marine Micropal.*, 4, p. 321 - 325.
- Oszczypko-Clowes, M., 2000, Oligocene paleogeography and nannofossil paleoecology of the Magura Basin (Western Carpathians). *Slovak Geol. Mag.*, 6, 2 - 3, p. 175 – 177, Bratislava.
- Patrulus, D., Lupu, M., Borcoș, M., 1968, *Harta geologică scara 1:200.000, foaia Șimleul Silvaniei*. Notă explicativă. București.
- Perch-Nielsen, K., 1985, Cenozoic calcareous nannofossils. In: Bolli, Saunders, Perch-Nielsen (Eds.). *Plankton Stratigraphy*, Cambridge Univ. Press, Cambridge.

- Popescu, B., 1978, On the lithostratigraphic nomenclature of the NW Transylvania Eocene. *Rev. Roum. Geol. Geophys., Geogr., Geol.*, 22, p. 99 – 107, 2 tab., Bucureşti.
- Popescu, B., Bombiţă G., Rusu, A., Iva, M., Gheţa N., Olteanu, R., Popescu, D., Tăutu, E., 1978, The Eocene of the Cluj – Huedin area. *D. S. Inst. Geol.*, 64, 4, p. 295 – 376, 7 figs., 3 tab., 24 pls., Bucureşti.
- Rusu, A., 1970, Corelarea faciesurilor Oligocenului din regiunea Treznea – Buzuşa. (NV Bazinului Transilvaniei). *Studii şi Cercetări Geol., Geof., Geogr.*, ser. Geol., 15, 2, p. 513 – 525, Bucureşti.
- Rusu, A., 1977, Stratigrafia depozitelor oligocene din nord-vestul Transilvaniei (Regiunea Treznea – Hida – Poiana Blenchii). *An. Inst. Geol., Geof.*, 51, p. 69 - 223, 14 figs., 31 pls., Bucureşti.
- Rusu, A. 1995. Eocene Formations in the Calata Region (NW Transylvania). *Rom. J. Tect & Reg. Geol.*, 76, p. 59 – 72, Bucureşti.
- Varol, O., 1998, *Paleogene*. In: *Calcareous Nannofossil Biostratigraphy*. In Bown, P. R. (Ed.), Chapman & Hall, p. 200 - 224, London.
- Young, J., R., Bown, P. R., 1997, Cenozoic calcareous nannoplankton classification. *Journal of Nannoplankton Research*, 19, 1, p. 15 – 47.

PLATE CAPTIONS

Plate I Fig. (x 2.000):

- 1a, 1b – *Ericsonia subdisticha* Roth & Hay in Hay et al., 1a - NII; 1b - N+; Hodiş.
- 2a, 2b – *Istmolithus recurvus* Stradner. 2a - NII; 2b - N+; Hodiş.
- 3a, 3b – *Markalius inversus* Deflandre in Deflandre & Fert. 3a - NII; 3b - N+ Hodiş.
- 4a, 4b – *Markalius sp.* 4a - NII; 4b - N+;
- 5a, 5b – *Biantholithus sparsus* Bramlette & Martini. 5a – NII; 5b – N+; Hodiş.
- 6a, 6b – *Zygrhablithus bijugatus* Deflandre in Deflandre & Fert. 6a - NII; 6b - N+; Hodiş.

Plate II Fig. (x 2.000):

- 1 – *Discoaster tani* Bramlette & Riedel. NII; Hodiş
- 2, 3 – *Discoaster tani nodifer* Bramlette & Riedel. NII; Hodiş.
- 4 – *Corannulus germanicus* Stradner. NII; Hodiş.
- 5 – *Lithostromation perdurum* Deflandre. NII; Hodiş.
- 6 – *Tribrachiatus bramlettei* Broennimann & Stradner. NII; Hodiş.
- 7a, 7b – *Pontosphaera lateliptica* Baldi-Beke & Baldi. 7a - NII; 7b – N+; Hodiş.
- 8a, 8b – *Pontosphaera formosa* Bukry & Bramlette. 8a - NII; 8b – N+; Hodiş.
- 9a, 9b – *Pontosphaera bicaveata* Pearch-Nielsen. 9a – NII; 9b - N+; Hodiş.

Plate III Fig. (x 2.000):

- 1a, 1b – *Pontosphaera enormis* Locker. 1a - NII; 1b - N+; Hodiş.
- 2a, 2b – *Helicosphaera cf. reticulata* Baldi-Beke. 2a - NII; 2b - N+; Hodiş.
- 3a, 3b – *Pontosphaera pulchra* Romein. 3a - NII; 3b - N+; Hodiş.
- 4a, 4b – *Reticulofenestra dictyoda* Deflandre in Deflandre & Fert. 4a - NII; 4b - N+; Tetiş.
- 5a, 5b – *Dictyococites cf. danicus* Black. 5a - NII; 5b – N+; Hodiş.
- 6a, 6b – *Chiasmolithus gigas* Bramlette & Sullivan. 6a - NII; 6b - N+; Hodiş.

Plate IV Fig. (x 2.000):

- 1a, 1b – *Lanternitus minutus* Stradner. *Sphenolithus pseudoradians* Bramlete & Wilcoxon; 1a - NII; 1b - N+; Hodiş.
2a, 2b – *Sphenolithus pseudoradians* Bramlete & Wilcoxon. 2a - NII; 2b - N+; Hodiş.
3a, 3b – *Rabdosphaera creber* Deflandre in Deflandre & Fert. 3a - NII; 3b - N+; Hodiş.
4a, 4b – *Dictiococites bisectus* Hay, Mohler, Wade. 4a - NII; 4b - N+; Hodiş.
5a, 5b – *Braarudosphaera bigelowii* Gran & Braarud. 5a - NII; 5b – N+ Tetiş.
6a, 6b – *Blakites spinosus* Deflandre & Fert. 6a - NII; 6b - N+; Hodiş.

Plate V Fig. (x 2.000):

- 1a, 1b – *Cyclicargolithus luminis* . 1a - NII; 1b - N+; Hodiş.
2a, 2b – *Reticulofenestra reticulata* Gartner & Smith. 2a – NII; 2b - N+; Hodiş.
3a, 3b – *Coccolithus eopelagicus* Bramlette & Riedel. 3a - NII; 3b - N+; Hodişu.
4a, 4b – *Coccolithus formosus* Kampter. 4a – NII; 4b – N+; Tetişu.
5 – *Reticulofenestra hillae* Bukry & Percival. N+; Hodişu.
6 – *Reticulofenestra umbilica* Levin. N+; Hodişu.
7a, 7b – *Thoracosphaera cf. heimii* Lohmann. 7a – NII; 7b – N+; Hodişu

PLATE I

1a

1b

2a

3a

3b

2b

4a

4b

5a

6a

6b

5b

PLATE II

1

2

3

4

5

6

7a

7b

8a

9a

9b

8b

PLATE III

1a

1b

2a

3a

3b

2b

4a

4b

5a

6a

6b

5b

PLATE IV

1a

1b

2a

2b

3a

3b

4a

4b

5a

6a

6b

5b

PLATE V